What is claimed is:

1. An isolated nucleic acid molecule encoding a motor neuron restricted pattern, MNR2, protein.

2. The isolated nucleic acid of claim 1 which is a DNA molecule.

3. The isolated nucleic acid of claim 2 which is a cDNA molecule.

4. The isolated nucleic acid of claim 1 which is a RNA molecule.

5. The isolated nucleic acid of claim 1 operatively linked to a promoter of RNA transcription.

6. A vector which comprises the isolated nucleic acid of claim 1, operatively linked to a promoter of RNA transcription.

7. A plasmid comprising the vector of claim 6.

8. The plasmid of claim 7 designated pMNR2 (ATCC Accession No. 203294.

9. The isolated nucleic acid molecule of claim 3, wherein the nucleic acid molecule encodes a chick MNR2 protein.

10. The isolated nucleic acid molecule of claim 9, wherein the nucleic acid molecule encodes a MNR2 protein comprising the amino acid sequence set forth in SEQ ID NO: 1.

11. The isolated nucleic acid molecule of claim 3, wherein the nucleic acid molecule encodes a mammalian MNR2 protein.

12. The isolated nucleic acid molecule of claim 11, wherein the mammalian MNR2 protein is mouse, rat, or human protein.

13. The isolated nucleic acid of claim 3 which comprises the nucleic acid sequence set forth in SEQ ID NO: 1.

14. A host cell containing the vector of claim 6.

15. The host cell of claim 14, wherein the cell is selected from a group consisting of a bacterial cell, a plant cell, an insect cell, and a mammalian cell.

16. A method of producing a polypeptide having the biological activity of a mammalian MNR2 which comprises growing the host cells of claim 15 under suitable conditions permitting production of the polypeptide.

17. The method of claim 16 further comprising recovering the produced polypeptide.

18. An isolated nucleic acid molecule of at least 15 contiguous nucleotides capable of specifically hybridizing with a unique sequence included within the sequence of the nucleic acid molecule of claim 1.

19. The isolated nucleic acid of claim 18 which is a DNA molecule.

20. The isolated nucleic acid of claim 18 which is a RNA molecule.

21. An isolated nucleic acid molecule capable of specifically hybridizing with a unique sequence included within the sequence of a nucleic acid molecule which is complementary to the nucleic acid molecule of claim 1.

22. The isolated nucleic acid of claim 21 which is a DNA molecule.

23. The isolated nucleic acid of claim 21 which is a RNA molecule.

24. An antisense oligonucleotide having a nucleic acid sequence capable of specifically hybridizing to an mRNA molecule encoding a MNR2 protein.

25. An antisense oligonucleotide having a nucleic acid sequence capable of specifically hybridizing to the cDNA molecule of claim 3.

26. An antisense oligonucleotide having a nucleic acid sequence capable of specifically hybridizing to the RNA molecule of claim 4.

27. A purified MNR2 protein.

28. A purified MNR2 protein encoded by the isolated nucleic acid of claim 1.

29. A purified unique polypeptide fragment of the MNR2 protein of claim 28.

30. The MNR2 protein of claim 28 having substantially the same amino acid sequence as set forth in SEQ ID NO: 1.

31. The MNR2 protein of claim 28 having the amino acid sequence as set forth in SEQ ID NO: 1.

32. The MNR2 protein of claim 31 which is a vertebrate MNR2 protein.

33. The vertebrate MNR2 protein of claim 32 which is a chick, mouse, rat, or human MNR2 protein.

SUB A2

34. A monoclonal antibody directed to an epitope of an MNR2 protein of claim 33.

35. A monoclonal antibody of claim 34 directed to a chick, mouse, rat or human MNR2 protein.

36. A polyclonal antibody directed to an epitope of the MNR2 protein of claim 31.

37. A polyclonal antibody of claim 36 directed to a chick, mouse, rat or human MNR2 protein.

38. A method of inducing differentiation somatic motor neurons which comprises expressing MNR2 protein in neural progenitor cells.

39. The method of claim 38, wherein the expression of MNR2 protein induces expression of transcription factors Isl2, Lim 3 and HB9.

40. The method of claim 38, wherein the neural progenitor cells are spinal cord motor neuron progenitor cells or hindbrain motor neuron progenitor cells.

41. A transgenic nonhuman mammal which comprises an isolated DNA molecule of claim 2.

42. The transgenic nonhuman mammal of claim 41, wherein the DNA encoding a MNR2 protein is operatively linked to tissue specific regulatory elements.

43. A method of determining physiological effects of expressing varying levels of MNR2 protein in a transgenic nonhuman mammal which comprises producing a panel of transgenic nonhuman animals, each transgenic nonhuman mammal expressing a different amount of MNR2 protein.

44. A method of producing the isolated protein of either of claims 27 or 28 which comprises:

(a) inserting a nucleic acid molecule encoding a MNR2 protein into a suitable vector;

(b) introducing the resulting vector into a suitable host cell;

(c) selecting the introduced host cell for the expression of the MNR2 protein;

(d) culturing the selected cell to produce the MNR2 protein; and

(e) recovering the MNR2 protein produced.

45. A method of inducing differentiation of somatic motor neurons in a subject comprising administering to the subject the purified MNR2 protein of either of claims 27 or 28 in an amount effective to induce differentiation of somatic motor neurons in the subject.

46. The method of claim 45 wherein the subject is a mammal.

47. The method of claim 46, wherein the mammal is a mouse, rat or human.

48. A pharmaceutical composition comprising a purified MNR2 protein of either of claims 27 or 28 and a pharmaceutically acceptable carrier.

49. A method for treating a subject afflicted with an abnormality associated with a lack of one or more normally functioning motor neurons which comprises introducing an amount of the pharmaceutical composition of claim 48 effective to generate somatic motor neurons from undifferentiated motor neuron precursor cells in the subject, thereby treating the subject afflicted with the abnormality associated with the lack of one or more normally functioning motor neurons.

50. A method of treating a subject afflicted with a neurodegenerative disease which comprises introducing an amount of the pharmaceutical composition of claim 48 effective to generate somatic motor neurons from undifferentiated precursor motor neuron cells in the subject, thereby treating the subject afflicted with the neurodegenerative disease.

51. The method of claim 49 wherein the generation of motor neurons from undifferentiated precursor motor neuron cells alleviates a chronic neurodegenerative disease.

52. A method of treating a subject afflicted with an acute nervous system injury which comprises introducing an amount of pharmaceutical composition of claim 48 effective to generate motor neurons from undifferentiated precursor motor neuron cells in a subject, thereby treating the subject afflicted with the acute nervous system injury.

53. The method of claim 52 wherein the acute nervous system injury is localized to a specific central axon which comprises surgical implantation of the

pharmaceutical composition of claim 48 effective to generate motor neurons from undifferentiated precursor motor neuron cells located proximal to the specific central axon, so as to alleviate the acute nervous system injury localized to a specific central axon, thereby treating the subject afflicted with the acute nervous system injury.

54. The method of claim 51 wherein the chronic neurodegenerative disease is spinal muscular atrophies.

55. The method of claim 51 wherein the chronic neurodegenerative disease is myotrophic lateral sclerosis.

56. A method for diagnosing a chronic neurodegenerative disease associated with the expression of a MNR2 protein in a sample from a subject which comprises:

(a) obtaining DNA from the sample of the subject suffering from the chronic neurodegenerative disease;

(b) performing a restriction digest of the DNA with a panel of restriction enzymes;

(c) separating the resulting DNA fragments by size fractionation;

(d) contacting the resulting DNA fragments with a nucleic acid probe capable of specifically hybridizing with a unique sequence included within the sequence of a nucleic acid molecule encoding a MNR2 protein, wherein the sequence of a nucleic acid molecule encoding a MNR2 protein is linked at a specific break point to a

specified nucleic acid sequence and labeled with a detectable marker;

(e) detecting labeled bands which have hybridized to the nucleic acid probe capable of specifically hybridizing with a unique sequence included within the sequence of a nucleic acid molecule encoding a MNR2 protein, wherein the sequence of a nucleic acid molecule encoding a MNR2 protein is linked at a specific break point to a specified nucleic acid sequence to create a unique band pattern specific to the DNA of subjects suffering from the chronic neurodegenerative disease;

(f) preparing DNA obtained from a sample of a subject for diagnosis by steps (a-e); and

(g) comparing the detected band pattern specific to the DNA obtained from a sample of subjects suffering from the chronic neurodegenerative disease from step (e) and the DNA obtained from a sample of the subject for diagnosis from step (f) to determine whether the patterns are the same or different and to diagnose thereby predisposition to the chronic neurodegenerative disease if the patterns are the same.

57. A method for diagnosing a chronic neurodegenerative disease associated with the expression of a MNR2 protein in a sample from a subject which comprises:

(a) obtaining RNA from the sample of the subject suffering from chronic neurodegenerative disease;

(b) separating the RNA sample by size fractionation;

(c) contacting the resulting RNA species with a nucleic acid probe capable of specifically hybridizing with a unique sequence included within the sequence of a nucleic acid molecule encoding a MNR2 protein, wherein the sequence of a nucleic acid molecule encoding a MNR2 protein is linked at a specific break point to a specified nucleic acid sequence and labeled with a detectable marker;

(d) detecting labeled bands which have hybridized to the RNA species to create a unique band pattern specific to the RNA of subjects suffering from the chronic neurodegenerative disease;

(e) preparing RNA obtained from a sample of a subject for diagnosis by steps (a-d); and

(f) comparing the detected band pattern specific to the RNA obtained from a sample of subjects suffering from the chronic neurodegenerative disease from step (d) and the RNA obtained from a sample of the subject for diagnosis from step (f) to determine whether the patterns are the same or different and to diagnose thereby predisposition to the chronic neurodegenerative disease if the patterns are the same.

58. A functionally equivalent analog of MNR2 that induces MNR2 differentiation of neural progenitor cells.

59. A functionally equivalent analog of MNR2 that prevents MNR2 differentiation of neural progenitor cells.

60. A method of treating a subject afflicted with a neuromuscular disease which comprises introducing an amount of the pharmaceutical composition of claim 48

effective to activate acetylcholine to activate muscle cells.

61. An isolated nucleic acid molecule encoding a homeobox, HB9, protein.

62. The isolated nucleic acid of claim 61 which is a DNA molecule.

63. The isolated nucleic acid of claim 62 which is a cDNA molecule.

64. The isolated nucleic acid of claim 61 which is a RNA molecule.

65. The isolated nucleic acid of claim 61 operatively linked to a promoter of RNA transcription.

66. A vector which comprises the isolated nucleic acid of claim 61, operatively linked to a promoter of RNA transcription.

67. A plasmid comprising the vector of claim 66.

68. The plasmid of claim 67 designated pHB9

69. The isolated nucleic acid molecule of claim 63, wherein the nucleic acid molecule encodes a chick HB9 protein.

70. The isolated nucleic acid molecule of claim 69, wherein the nucleic acid molecule encodes a HB9 protein comprising the amino acid sequence set forth in SEQ ID NO: 1.

71. The isolated nucleic acid molecule of claim 63, wherein the nucleic acid molecule encodes a mammalian HB9 protein.

72. The isolated nucleic acid molecule of claim 71, wherein the mammalian HB9 protein is mouse, rat, or human protein.

73. The isolated nucleic acid of claim 63 which comprises the nucleic acid sequence set forth in SEQ ID NO: 1.

74. A host cell containing the vector of claim 66.

75. The host cell of claim 64, wherein the cell is selected from a group consisting of a bacterial cell, a plant cell, an insect cell, and a mammalian cell.

76. A method of producing a polypeptide having the biological activity of a mammalian HB9 which comprises growing the host cells of claim 65 under suitable conditions permitting production of the polypeptide.

77. The method of claim 66 further comprising recovering the produced polypeptide.

78. An isolated nucleic acid molecule of at least 15 contiguous nucleotides capable of specifically hybridizing with a unique sequence included within the sequence of the nucleic acid molecule of claim 61.

79. The isolated nucleic acid of claim 68 which is a DNA molecule.

80. The isolated nucleic acid of claim 68 which is a RNA molecule.

81. An isolated nucleic acid molecule capable of specifically hybridizing with a unique sequence included within the sequence of a nucleic acid molecule which is complementary to the nucleic acid molecule of claim 61.

82. The isolated nucleic acid of claim 81 which is a DNA molecule.

83. The isolated nucleic acid of claim 81 which is a RNA molecule.

84. An antisense oligonucleotide having a nucleic acid sequence capable of specifically hybridizing to an mRNA molecule encoding a HB9 protein.

85. An antisense oligonucleotide having a nucleic acid sequence capable of specifically hybridizing to the cDNA molecule of claim 63.

86. An antisense oligonucleotide having a nucleic acid sequence capable of specifically hybridizing to the RNA molecule of claim 64.

87. A purified HB9 protein.

88. A purified HB9 protein encoded by the isolated nucleic acid of claim 61.

89. A purified unique polypeptide fragment of the HB9 protein of claim 88.

90. The HB9 protein of claim 88 having substantially the same amino acid sequence as set forth in SEQ ID NO: 1.

91. The HB9 protein of claim 88 having the amino acid sequence as set forth in SEQ ID NO: 1.

92. The HB9 protein of claim 91 which is a vertebrate HB9 protein.

93. The vertebrate HB9 protein of claim 92 which is a chick, mouse, rat, or human HB9 protein.

94. A monoclonal antibody directed to an epitope of an HB9 protein of claim 93.

95. A monoclonal antibody of claim 94 directed to a chick, mouse, rat or human HB9 protein.

96. A polyclonal antibody directed to an epitope of the HB9 protein of claim 91.

97. A polyclonal antibody of claim 96 directed to a chick, mouse, rat or human HB9 protein.

98. A method of inducing differentiation somatic motor neurons which comprises expressing HB9 protein in neural progenitor cells.

99. The method of claim 98, wherein the expression of HB9 protein induces expression of transcription factors Isl2, Lim 3 and HB9.

100. The method of claim 98, wherein the neural progenitor cells are spinal cord motor neuron progenitor cells or hindbrain motor neuron progenitor cells.

101. A transgenic nonhuman mammal which comprises an isolated DNA molecule of claim 62.

102. The transgenic nonhuman mammal of claim 101, wherein the DNA encoding a HB9 protein is operatively linked to tissue specific regulatory elements.

103. A method of determining physiological effects of expressing varying levels of HB9 protein in a transgenic nonhuman mammal which comprises producing a panel of transgenic nonhuman animals, each transgenic nonhuman mammal expressing a different amount of HB9 protein.

104. A method of producing the isolated protein of either of claims 87 or 88 which comprises:

(a) inserting a nucleic acid molecule encoding a HB9 protein into a suitable vector;

(b) introducing the resulting vector into a suitable host cell;

(c) selecting the introduced host cell for the expression of the HB9 protein;

(d) culturing the selected cell to produce the HB9 protein; and

(e) recovering the HB9 protein produced.

105. A method of inducing differentiation of somatic motor neurons in a subject comprising administering to the subject the purified HB9 protein of either of claims 87 or 88 in an amount effective to induce differentiation of somatic motor neurons in the subject.

106. The method of claim 105 wherein the subject is a mammal.

107. The method of claim 106, wherein the mammal is a mouse, rat or human.

108. A pharmaceutical composition comprising a purified HB9 protein of either of claims 87 or 88 and a pharmaceutically acceptable carrier.

109. A method for treating a subject afflicted with an abnormality associated with a lack of one or more normally functioning motor neurons which comprises

introducing an amount of the pharmaceutical composition of claim 108 effective to generate somatic motor neurons from undifferentiated motor neuron precursor cells in the subject, thereby treating the subject afflicted with the abnormality associated with the lack of one or more normally functioning motor neurons.

110. A method of treating a subject afflicted with a neurodegenerative disease which comprises introducing an amount of the pharmaceutical composition of claim 108 effective to generate somatic motor neurons from undifferentiated precursor motor neuron cells in the subject, thereby treating the subject afflicted with the neurodegenerative disease.

111. The method of claim 109 wherein the generation of motor neurons from undifferentiated precursor motor neuron cells alleviates a chronic neurodegenerative disease.

112. A method of treating a subject afflicted with an acute nervous system injury which comprises introducing an amount of pharmaceutical composition of claim 108 effective to generate motor neurons from undifferentiated precursor motor neuron cells in a subject, thereby treating the subject afflicted with the acute nervous system injury.

113. The method of claim 112 wherein the acute nervous system injury is localized to a specific central axon which comprises surgical implantation of the pharmaceutical composition of claim 108 effective to generate motor neurons from undifferentiated precursor motor neuron cells located proximal to the specific central axon, so as to alleviate the acute nervous system injury localized to a specific central axon,

thereby treating the subject afflicted with the acute nervous system injury.

114. The method of claim 111 wherein the chronic neurodegenerative disease is spinal muscular atrophies.

115. The method of claim 111 wherein the chronic neurodegenerative disease is myotrophic lateral sclerosis.

116. A method for diagnosing a chronic neurodegenerative disease associated with the expression of a HB9 protein in a sample from a subject which comprises:

(a) obtaining DNA from the sample of the subject suffering from the chronic neurodegenerative disease;

(b) performing a restriction digest of the DNA with a panel of restriction enzymes;

(c) separating the resulting DNA fragments by size fractionation;

(d) contacting the resulting DNA fragments with a nucleic acid probe capable of specifically hybridizing with a unique sequence included within the sequence of a nucleic acid molecule encoding a HB9 protein, wherein the sequence of a nucleic acid molecule encoding a HB9 protein is linked at a specific break point to a specified nucleic acid sequence and labeled with a detectable marker;

(e) detecting labeled bands which have hybridized to the nucleic acid probe capable of specifically hybridizing with a unique sequence included

within the sequence of a nucleic acid molecule encoding a HB9 protein, wherein the sequence of a nucleic acid molecule encoding a HB9 protein is linked at a specific break point to a specified nucleic acid sequence to create a unique band pattern specific to the DNA of subjects suffering from the chronic neurodegenerative disease;

(f) preparing DNA obtained from a sample of a subject for diagnosis by steps (a-e); and

(g) comparing the detected band pattern specific to the DNA obtained from a sample of subjects suffering from the chronic neurodegenerative disease from step (e) and the DNA obtained from a sample of the subject for diagnosis from step (f) to determine whether the patterns are the same or different and to diagnose thereby predisposition to the chronic neurodegenerative disease if the patterns are the same.

117. A method for diagnosing a chronic neurodegenerative disease associated with the expression of a HB9 protein in a sample from a subject which comprises:

(a) obtaining RNA from the sample of the subject suffering from chronic neurodegenerative disease;

(b) separating the RNA sample by size fractionation;

(c) contacting the resulting RNA species with a nucleic acid probe capable of specifically hybridizing with a unique sequence included within the sequence of a nucleic acid molecule encoding a HB9 protein, wherein the sequence of a nucleic acid molecule encoding a HB9 protein is linked at a specific break point to a specified

nucleic acid sequence and labeled with a detectable marker;

(d) detecting labeled bands which have hybridized to the RNA species to create a unique band pattern specific to the RNA of subjects suffering from the chronic neurodegenerative disease;

(e) preparing RNA obtained from a sample of a subject for diagnosis by steps (a-d); and

(f) comparing the detected band pattern specific to the RNA obtained from a sample of subjects suffering from the chronic neurodegenerative disease from step (d) and the RNA obtained from a sample of the subject for diagnosis from step (f) to determine whether the patterns are the same or different and to diagnose thereby predisposition to the chronic neurodegenerative disease if the patterns are the same.

118. A functionally equivalent analog of HB9 that induces HB9 differentiation of neural progenitor cells.

119. A functionally equivalent analog of HB9 that prevents HB9 differentiation of neural progenitor cells.

120. A method of treating a subject afflicted with a neuromuscular disease which comprises introducing an amount of the pharmaceutical composition of claim 108 effective to activate acetylcholine to activate muscle cells.

121. A method of treating an embryo afflicted with sacral agenesis which comprises introducing the isolated nucleic acid of claim 61 into the embryo.

122. A method of treating an embryo afflicted with sacral agenesis which comprises introducing an amount of the pharmaceutical composition of claim 108.

123. A method of treating an embryo lacking HB9 expression which comprises introducing the isolated nucleic acid of claim 61.

124. A method of treating an embryo lacking HB9 expression which comprises introducing an amount of the pharmaceutical composition of claim 108.